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STREETS.*

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From "Engineering."

The object of this paper is to describe the street coverings now most used, and to show their relative advantages and defects. But before we can weigh these fairly, or form reasonable opinions regarding them, we must have distinct ideas about the nature of roads in general, ond we must find out what a good road really is. I shall, therefore, in the first place endeavor to make a comprehensive theory of roads, and in order to do this shall enumerate and describe the qualities which a good road ought to possess. We shall thus see what ends road-makers should aim at, and what difficulties they have to overcome. Secondly, I shall proceed to apply this general theory of roads to one particular case, viz., streets, dividing all kinds of modern streets into four great classes:—

1. Macadam, and macadam concrete streets.
II. Streets paved with stone setts.
III. Streets paved with wood.
IV. Streets paved with Asphalte.

Thus you may see that having found out what a road is, our attention will be confined to the roads now made in this country, or in countries like it in civilization and physical features; and further, that it will be confined to these in or near cities where the traffic is large and heavy, that is to say, to streets.

Having adopted these limits, we will not enter upon such subjects as the ancient and modern history of roads,—the principles which guide their exploration,—the methods of construction adopted in remote colonies and western states,—or the working of our own highway Acts. Passing references will however be made to history, whenever it affords us useful hints, either in the way of example or warning. Finally, I must explain that this paper is no record of original observation or experiments. Still, I venture to hope that it will not be found uninteresting or useless. In the first place, the theories of some of those who have made roads well, or had them long under their charge, are stated and examined; so that, if possible, we may compile a sound and comprehensive theory of our own. Secondly, a good many facts have been collected from various scattered sources and grouped together, so that they may be easily referred to and compared. The consideration of these facts will, I hope, show the relative advantages of the four kinds of streets already mentioned. Having thus cleared and defined our ground, we may now endeavor to answer the question, "What is a good road?"

It is not easy to do this in a single sentence, therefore it seems best to adopt the method already indicated and enumerate the qualities which a good road ought to possess. These are:

I. *Surface Hardness.*— Wheels and horses' feet must not sink or cut into its substance. Brittle hardness might be enough to prevent this, but a road surface must have toughness; must stand the wear caused by the rolling or grinding of the traffic, also the blows from the horse's hoofs, and the jolting and concussion of vehicles.

II. *Smoothness.*—When this quality is combined with hardness, we at once obtain five things which are of great value to all connected with roads.

1. *Minimum Wear of Surface.*—It is a euphemism to speak of a carriage rolling along a road, as the real motion is of a very different kind. Let us watch an empty cab, while being driven quickly over an ordinary granite pavement. This is certainly an extreme case, but for that reason it shows clearly the action which takes place. It can easily be seen that the cab advances by a series of small jumps, and gives pretty sharp blows to the setts which it happens to strike. This is caused by inequalities in the road, particularly at the joints of the stones, and the same thing happens more or less in connection with every kind of traffic, no matter how heavy and slow; and on every kind of pavement, no matter how hard and smooth. The stones are thus ground or chipped away, besides being gradually knocked out of position and forced down into the substratum. Vehicles act chiefly, though not altogether, on the surface of the setts, but horses principally chip off their edges, and give them a rounded shape, by their endeavours to get firm foothold. This is proved by the fact that between tramway rails where the setts are chiefly exposed to the action of hoofs, they become more rounded on the top than those subjected to general traffic in adjacent parts of the street. On a smooth, hard surface, there is comparatively no jolting and little abrasion, and, by reducing these, we shall evidently save material and lengthen the period during which the road will remain in good form.

2. *Minimum Wear of Vehicles.*—The wear of vehicles must no doubt be an important item, though it is not easy to estimate. Jolting is at least as bad for the vehicle as the road, and a considerable sum can be saved to the community by making hard, smooth roadway.

3. *Minimum Noise.*—This becomes a desideratum where the traffic is incessant.

4. *Minimum Draught.*—The effects of different degrees of hardness and smoothness on draught have often been experimentally determined, and the results practically agreed, although obtained in different places and at various periods. A few of them may be referred to here, as they conclusively show the importance of these qualities. At the Royal Agricultural Society's Bedford Show last summer, the average draught of seventeen carts was found to be 39 lb. per ton on an macadamized road, at 2½ miles per hour, and 140 lb. per ton on a field, at 2¾ miles per hour. Sir John MacNeill's results are rather higher, being 46 lb. to 65 lb. per ton on macadam, and 147 lb. per ton on gravel; but such small differences need not surprise us, when we consider the impossibility of making the experiments in precisely similar circumstances. Other instances might be given, in which it might be found that the draught was increased from 3 to 5 times, by allowing roads to get into bad order, or by putting on new metal. For the sake of comparison, it may be mentioned that the draught on a railway, which is merely a very perfect kind of road, would probably not exceed 10 lb. per ton. Now, diminished draught means, that each horse is enabled to do more work, or to do the same amount of work with less exertion and straining,—and, in either case, there will be considerable saving to their owners. Such considerations prove the advantages of having the least possible draught, and show that it can be obtained by making road surfaces hard and smooth.

5. *Cleanliness.*—We have seen how rough roads are worn away by the traffic. Now, the small *debris* ground and chipped off the material, forms mud or dust, according to the state of the weather. To a certain extent mud is also caused by the subsoil working up through the joints of the stones. But however caused, their evil effects are manifold. Dust, especially in cities, often consists to a large extent of poisonous organic particles, which people are apt to enhale. The poor cannot

* Paper read before the Edinburgh and Leith Society.

keep their houses clean if they are constantly going out and in with dirty clothes and boots; and we all know that cleanliness is essential to social well-being. The rich suffer too. Their furniture is often destroyed by the dirt. Shopkeepers also frequently lose considerable sums, owing to the injury it does to their goods. Moreover, mud is very injurious to the road itself. A clean road wears better than a dirty one. From what has been said, it will be seen that the quantity of mud carted away is a measure at the rate at which the material of the road is consumed. Thus, in Dublin at one time the quantity of mud annually removed was greater than the quantity of metal annually laid on; and accordingly, the surface of the roads was gradually being lowered. Again, when machine-sweeping was introduced into Manchester owing to the reduced cost, certain streets were swept three times as often as formerly, but the quantity of mud removed was actually diminished. Mud keeps the road damp, and this softens the subsoil, making it work up through the joints, and thus increasing the amount of dirt to be removed. Besides, when the subsoil is in this damp, soft state, the setts are forced into it, and the road-surface becomes becomes uneven and full of holes. By keeping the road wet, mud also facilitates the grinding down of the stones, as a supply of water materially aids the process. But we must return to our list of qualities.

III. *Solidity.*—A road must have a firm substance, capable of resisting the weight of the traffic. A certain amount of bulk is necessary, because a pressure may crush a 3-in. cube, which would have no affect on a 12-in. one. The theoretical pressure of loaded vehicles does not vary much. Telford (probably founding his opinion on the practice of the time), thought it should not exceed 1 ton on each wheel, the tyre being 4 in. wide, that is 5 cwt. per inch of width of tyre. This opinion seems still to be held by cart-makers, for at the recent Bedford Show, the average weight per inch of width of tyre was 4½ cwt., the maximum and minimum being respectively 3½ and 5½ cwt. The weight of road rollers is about the same. Aveling and Porter's 30-ton roller exerts a pressure of about 5½ cwt. per inch of width, and that of their 15-ton roller is only about 4 cwt. per inch of width. Pickford's vans and London omnibuses are exceptionally heavy, being sometimes loaded up to 8½ cwt. per inch. Such are the calculated pressures in in some instances, but it is difficult to say to what extent they may be increased, owing to tyres becoming convex.

IV. *Elasticity.*—The importance of this quality is perhaps not obvious at first sight, and as it is yet scarcely sufficiently recognized by road makers, I shall devote a few minutes to its consideration. Macadam thought that a certain amount of elasticity was essential to the endurance of his roads. He preferred a soft foundation, and noticed that a part of the road from Bridgewater to Cross, which was laid on a bog, and actually shook when a carriage went along it, consumed less metal, and was more easily kept in repair, than neighboring portions laid on limestone rock. He thought that a road was to some extent an arch, and supported the pressure of the traffic by its capacity of resisting inclined strains, as well by its density. Telford, on the other hand, insisted on having a solid foundation, and seem to ignore the advantages derived from elasticity. He held that a road was only a hard, solid body, which would prevent the wheels from sinking into the ground. Telford's system has been more generally adopted than Macadam's, though I think experience shows that the latter was right in endeavouring to make elastic roadways. It is now generally admitted to be most important that road coverings should possess this quality, and engineers have come to this conclusion by observing railways. I have already remarked that a railway may be considered a very perfect road. The rails are hard, smooth, and solid, and carry enormous loads, moving at great speeds. Accordingly, whatever qualities are found to secure permanence and endurance in rails, will probably do the same for road-metal and pavements, though they may be required in a much less degree. Now, no one doubts the importance of elasticity in permanent way. The only question seems to be, whether rails, and even wheels, should be made a great deal more elastic than they are. The Committee of American Engineers on Rails, in their report, recently published, point out many ways in which it benefits the track, and I shall quote one or two of their remarks. "Too much stiffness diminishes the longevity of the rail. Inelastic roadbeds are among the causes of rails becoming unfit for service. When the stem is too thick, the rail is too rigid, and this increases the wear on the head, and the liability to break. Rails in winter often break, because the bed is frozen hard." So far the report. But besides all this, it has been observed that rails laid on soft ground, such as a bog or an embankment, are more easily kept in good surface, and are easier to run on, than those which are laid on a hard foundation.

Now, all these experimental facts prove, as far as railways are concerned, elasticity is absolutely necessary.

But why? We have seen its affects, but how does it produce them? According to one authority it "absorbs the effects of the blows of the wheels," or in the words of another, "it neutralizes the vibration arising from the impact of imperfect cylinders rolling on imperfect planes." And this is no doubt the case, though the precise nature of the concussion, or impact, may not be well understood. The empty cab jolting along over the granite may serve as a very rude specimen of the kind of action which takes place on a railway. Probably it is caused by the combination of three things,—1st, high speed; 2nd, imperfect workmanship, owing to which neither rails nor wheels are quite smooth, and the latter are badly balanced; and 3rd, the elasticity of the materials employed. I fear the first two are not likely to be removed, and it is certain that the last never will. This concussion, therefore, appears to be a thing which we cannot get rid of, and which it is better and and cheaper to meet, by giving considerable elasticity to rails and wheels, than by attempting to give them great theoretical perfection, that is to say, perfect smoothness and rigidity. Such an attempt would involve a large first cost, not to mention the cost and difficulty of maintenance. But whatever its nature, we have a rough idea of its amount, from the experiments of the Railway Iron Commissioners, in connexion with wrought-iron bridges.

They found that rapid motion might be supposed to add about one third to the load, and acting on these results, it is the universal practice to make the working strain one-third or one fourth of the breaking strain, according as the structure is to be free from or subject to vibration. In short we find that Macadam early observed the value of elasticity not till recently much acted on. We saw the importance attached to elastic rails by permanent way authorities, and having noticed these facts, we tried to ascertain the reasons which in the nature of things

cause them. These we find to be great speed, imperfect workmanship, and the inherent elasticity of our materials. We therefore came to the conclusion that we cannot get rid of these causes which make elasticity essential to the endurance of permanent way, and that we ought to try to neutralize the unavoidable impacts, by giving more of that quality to rails and wheels, rather than by attempting to make them perfectly smooth and rigid.

Finally all this applies in a less degree, but still a perfectly sensible degree, to roads. We are therefore led to suppose that elasticity will prove beneficial to road metal and pavements. This has been found to be the case, and the more this principle is acted on, the more this result will be confirmed. The chief benefit of elasticity is seen in the road itself; indirectly, however, it is advantageous to carriages, and this also can best be seen in railways.

(To be continued.)

SPECIFICATIONS

FOR THE

CONSTRUCTION OF SEWERS IN THE CITY OF CHICAGO, ILL., UNDER THE DIRECTION OF THE BOARD OF PUBLIC WORKS.

EXCAVATIONS.

These are to be made in such directions, and of such widths and depth as shall be necessary. Wherever the nature of the ground will admit of it, the bottom of the excavation must conform exactly to the ontside of the lower half of the sewer. The material excavated to be deposited on the side of the trenches, and beyond the reach of slides. All water or gas pipes of whatever kind or size, to be carefully supported and protected from injury by the contractor, either till the masonry and back-filling shall be finished, or till the officers of the water or gas works shall remove or change the pipes. Whenever necessary, timbers and planks shall be used to support the sides of the trenches. No allowance will be made for supporting the sides of the trenches with timbers or planks, unless they should be required to remain, in which case they are to be paid for by board measure.

In no case, without special permission, shall the excavation of trenches be more than one hundred feet in advance of the completed masonry.

FOUNDATIONS.

Whenever the soil is sufficiently firm, the masonry is to be laid directly on the bottom of the excavation; but whenever this shall not be the case, the contractor is to furnish and put in place, sand, gravel or boards (of suitable quality and dimensions) as may be required. In wet bottoms sufficient means must be provided to keep the work dry until the cement is perfectly set. No extra allowance will be made for pumping or bailing.

MATERIALS.

All materials of whatever nature, required in the construction of the sewers and drains, except bricks, pipes and manhole covers, to be furnished by the contractor, and to be approved by a duly appointed inspector before being used. All rejected materials to be removed immediately from the work, so as to effectually prevent their being used in it.

CENTERING AND PATTERNS.

All centering and patterns to be made strictly according to the plan or directions furnished, and so constructed as not to yield under any pressure to which they may be subjected. No centering to be removed before the back-filling over it is sufficiently completed to prevent any injury to the masonry.

MASONRY.

The mortar to be made by thoroughly incorporating two parts of clean sand with one of American Cement, equal in quality to the best Utica Cement which has been made in LaSalle County, Ill., mixed in a dry state, then adding just water enough to give it a proper consistency, and used as soon as practicable after being mixed. Extra cement, ordered to be used by the engineer in charge, will be paid for upon the estimate of the same.

Every brick must be clean, and thoroughly wet, if required, just before being laid. Whenever a difference occurs in the character of the brick for smoothness of surface, the best are to be used on the bottom and the poorest on the top of the two, two and one-quarter, and two and one-half foot sewers, which are to be formed of one ring or shell of wedge shaped or common bricks. The three, four, five, and six foot sewers are to be formed of two rings or shells, the smoothest bricks to be used on the bottom of the inside ring or shell, and the toughest, together with such broken ones as the inspector may direct to be used, on the outside ring or shell.

Every brick on the inside of the sewer to be laid fair and smooth by line, and to the true cylindrical form given for each case. The brick in each course are to be all stretchers, and to break joints with those in the adjoining courses. Every brick is to be thoroughly imbedded in mortar under its bottom and on its sides and ends, which is to be performed by one operation for each brick, and in no case shall mortar be worked in after the brick is laid. The joints between the courses shall not exceed half an inch in thickness, and between the rings or shells they shall not be less than half an inch.

The mortar joints on the inside of the sewers below the centre line to be carefully struck when laid, and those above to be scraped smooth with the brick work, immediately after the centres are struck; and the mortar scraped off and removed entirely from the sewer, which is to be left perfectly cleaned, and walled off at its ends.

Whatever precautions unforeseen circumstances may render necessary in the judgment of the Engineer, in order to make the sewers both unyielding and impervious, shall be taken, and all extra work or materials rendered necessary thereby, which may be ordered by the Engineer, shall be paid for at his estimate.

MAN-HOLES

Man-holes are to be of the form, dimensions and materials shown on the plans of the same, and of the same class of masonry as the sewers, so far as brick work and materials to be used.

OUTLETS.

The outlets or terminations of the sewers are to be made of stone or brick, laid in cement mortar, and of the form and dimensions shown on the plans.

All side junctions, whether for lateral sewers, catch-basins, or houses or lots, and whether of brick or pipe, are to be built into the sewers, wherever required, in as careful and thorough a manner as the rest of the work is done, and their ends to be effectually closed with brick and cement.

BACK-FILLINGS.

As soon as possible after the top of the sewer is closed up at any point, it is to be covered over with at least thirty inches of earth, and always to the top of the trench whenever that is more than thirty inches above the top of the masonry. This back-filling is to be put on carefully, in layers of not over six inches each, and each layer, before the next one is put on, to be either thoroughly wet or rammed, as the nature of the soil may render best, so as to prevent effectually all injury, from settling, to the sewers, and the necessity of unusual repairs to the streets. The back-filling to be made with earth taken from the trenches, as far as it will go, and any extra filling ordered will be paid for, extra, at a price per cubic yard as agreed upon. Sheet piling, where used, are not to be drawn before the trenches are filled.

All earth and other material thrown from the trenches, and not required for the back-filling are to be spread uniformly over the street, crowned up over the sewer, or thrown into the ditches, as may be required. All graveling, macadamizing, planking, culverts and cross-walks, are to be carefully removed before the trenches are dug, and are to be restored again to as good a condition as they were in previous to the commencement of the sewers, and to the satisfaction of the City Superintendent of Public Works.

PIPE-SEWERS.

So far as the specifications for the excavation and supporting sides of trenches, preparation of foundations and back-filling for the larger sewers, can be made to ap-

ply to the construction of the pipe sewers, they are to be followed. Each pipe is to be laid on a firm bed, and in perfect conformity with the lines and levels given. The ends of the pipe are to abut close against each other, in such a manner that there shall be no shoulder or want of uniformity of surface on the bottom of the interior of the drain. The rings are to be placed centrally around the joints of the pipes. The joints between the rings and the pipes are to be as uniform as possible in thickness, and thoroughly filled with the best American cement mortar, without sand or other substances, with only water enough to give proper consistency, and use as soon as made.

Pipes with branches for private drains are to be placed wherever required, and the ends of the branches for private drains are to be carefully closed with bricks and cement.

As often as once in every eighty feet, if required in the line of the pipes, there is to be a *man-hole*, built according to the plan furnished of the same.

GENERAL SPECIFICATION.

The Commissioners shall have the right to connect private drains with any of the sewers embraced in this agreement, so soon as said Board deem it expedient.

The Contractor shall be required to to guard the public effectually from liability to fall into the trenches, or from upsetting their vehicles against the earth thrown from them, during the whole progress of the work, both by night and by day; and will be held responsible for any damages the City may have to pay, in consequence of neglecting the necessary precautions. In addition to the necessary barriers, a red light must be maintained at night, at each end of the trench.

The Contractor will be required to dismiss from his employment all incompetent or unfaithful persons ; also to keep in perfect repair, for six months after its completion, the whole of his work, except in cases where the repairs may be rendered necessary by causes clearly beyond his control.

All of the work to be commenced and carried on at such times, and in such places, and in such a manner as the engineer shall direct; he being aided by his assistants and Inspectors, appointed for the purpose by the said Board. No work will be paid for unless accepted by the Engineer or some other person appointed by the said Board for the purpose. Payments of eighty-five per cent. in cash will be made monthly, on the Engineer's approximate estimate of the amount due each Contractor, and the remaining fifteen per cent. will be retained till the completion of the work, as security in part for its faithful performance. Bonds to an amount satisfactory to the said Board will be required as additional security. No Contractor will be paid a monthly estimate, after the first one, unless he has paid his workmen in full, up to the date of his previous estimate.

All the above specified work to be completed by.....unless the said Board should fail to furnish the bricks or pipes, or for any other cause find it necessary to suspend operations, in which case the Contractor shall be allowed further time, equal to the delay caused, but shall not be entitled to any damages of any kind or nature whatsoever for such delays.

No Contractor will be allowed to sublet the whole, or any part of his work, or make an assignment of the moneys to be paid to him, without special permission in writing from the said Board; and each Contractor will be required to give his personal attention to the work.

Any Contractor who shall fail to employ a sufficient force of competent men to complete the work he undertakes by the time specified, may be dismissed by the said Board; who shall, in such case, be authorized to complete said work at the cost of the Contractor.

Any bidder who shall fail to appear at the office of the Board of Public Works, either in person or by his agent, within two days after being addressed, through the post office of this city, or shall not, within three days, furnish the required security, shall forfeit his claim to the work.

The Board will reserve the right to reject any proposal, at their discretion.

Contractors will be required to dig all stake holes necessary to give the lines and levels for the work, in time for the daily visit of the Assistant Engineer in charge, at such times as he may appoint.

All railroads not required to be taken up must be kept in constant running order, and all railroads must be left, after the completion of the work, in as good condition as they were before its commencement, by the Contractor.

No allowance will be made for delays, or other damages, occasioned by the necessity of keeping the railroads in constant running order, or for removing and replacing the same when it is necessary to do so. All claims for extra labor or materials furnished by the Contractor, or for damages for any cause whatsoever, must be reported to the Inspector on the work at the time when such labor or materials are furnished, or such damages occur, and such claims must be presented to the Engineer in charge of the work at the end of the same month, by the Contractor ; otherwise the Board will not be bound to pay any such claims.

Water used from the city water pipes by the Contractor in the construction of work, will have to be paid for by him at the usual rates.

Bricks and other materials furnished by the city for the sewers, will be placed on the streets, as convenient to the work as possible. but no extra allowance will be made for moving them.

Wood's Patent Steam or Pneumatic Rock Drill.

The Rock Drilling Machine, of which we here present an illustration, is the result of a series of experiments began by Professor De Volson Wood, several years ago, while he was connected with the University of Michigan, and steadily persevered in since his connection with the Stevens Institute of Technology at Hoboken, N. J. That it is a difficult invention to perfect and bring into use, is acknowledged by all who have had any experience in similar undertakings. But Prof. Wood is an indefatigable worker, and although obliged to devote the principal portion of his time to his daily duties in the class-room, has found time to publish two books—which are now standard authority on the subjects of the construction of bridges and roofs, and on the strength of materials—besides keeping up his experiments on his invention. Collecting carefully the statistics of the efficiency of the various Rock Drills in this country and Europe, noting the difficulties that had to be overcome, and applying his theoretical knowledge to their solution, to be afterwards tested by actual experiment, and comparison with the best of similar machines in the country, he has, it is believed, succeeded in producing a Rock Drill that for a very great variety of work promises the most flattering results.

There are several sizes of the drill, but all are made after the same general style. We have not the space to enter into a detailed description of them, but for all such particulars refer our readers to Professor Wood, at Hoboken, N. J., who will furnish circulars, with large illustration of the machine, and an explanation of its construction and mode of using. As a specimen of the work of one of the three inch drills, we reprint a statement. that in a block of Quincy granite, in Newark, N. J., a hole 1½ inches in diameter was drilled 11¼ inches deep in 2½ minutes; in sandstone a hole same size was drilled 12 inches in one minute; and it is further stated that in a limestone quarry, where one of these machines has been at work for six months, it has done the work of twelve men.

To contractors, quarrymen, and others engaged in rock-work excavation, the Pneumatic Rock Drill must be what the mowing machine is to the farmer.

For the past two years, sixty or seventy American locomotives a year have been sent abroad at an annual valuation of nearly a million of dollars.

Table

OF ORDINATES AND CO-ORDINATES OF SEMI-ELLIPTIC AND SEMI-CIRCULAR ARCHES WHEN THE HEIGHT IS EQUAL TO 1.

5 Divisions.	10 Divisions.	20 Divisions.	25 Divisions.	50 Divisions.	100 Divisions.	Ordinates.	Co-Ordinates.
					1	.99995	.00005
				1	2	.9998	.0002
					3	.9996	.0004
			1	2	4	.9992	.0008
		1	.....	.....	5	.9988	.0013
				3	6	.9982	.0018
					7	.9976	.0024
			2	4	8	.9968	.0032
					9	.9959	.0041
	1	2		5	10	.995	.005
					11	.9939	.0061
			3	6	12	.9928	.0072
					13	.9915	.0085
				7	14	.9902	.0098
		3	.....	.....	15	.9887	.0113
			4	8	16	.9871	.0129
					17	.9854	.0146
				9	18	.9837	.0163
					19	.9818	.0182
1	2	4	5	10	20	.9793	.0202
					21	.9777	.0223
				11	22	.9755	.0245
					23	.9732	.0263
			6	12	24	.9708	.0292
		5	.....	.....	25	.9682	.0318
				13	26	.9656	.0344
					27	.9629	.0371
			7	14	28	.96.	.04
					29	.957	.043
	3	6		15	30	.9539	.0461
					31	.9507	.0493
			8	16	32	.9474	.0526
					33	.944	.056
				17	34	.9404	.0596
		7	.....	.....	35	.9368	.0632
			9	18	36	.933	.067
					37	.929	.071
				19	38	.925	.075
					39	.9208	.0792
2	4	8	10	20	40	.9165	.0835
					41	.9121	.0879
				21	42	.9075	.0925
					43	.9028	.0972
			11	22	44	.898	.102
		9	.....	.....	45	.893	.107
				23	46	.8879	.1121
					47	.8827	.1173
			12	24	48	.8773	.1227
					49	.8717	.1283
	5	10	.....	25	50	.866	.134
					51	.8602	.1398
			13	26	52	.8542	.1458
					53	.848	.152
				27	54	.8417	.1583
		11	.....	.....	55	.8352	.1648
			14	28	56	.8285	.1715
					57	.8216	.1784
				29	58	.8146	.1854
					59	.8074	.1926
3	6	12	15	30	60	.8	.2
					61	.7924	.2076
				31	63	.7846	.2154
					64	.7766	.2234
			16	32	64	.7684	.2316
		13	.....	.....	65	.7599	.2401
				33	66	.7513	.2487
					67	.7424	.2576
			17	34	68	.7332	.2667
					69	.7238	.2762
	7	14		35	70	.7141	.2859
					71	.7042	.2958
			18	36	72	.694	.306
					73	.6835	.3165
				37	74	.6726	.3274
		15	.....	.....	75	.6614	.3386
					76	.6499	.3501
					77	.638	.362
				39	78	.6258	.3742
					79	.6131	.3869
4	8	16	20	40	80	.6	.4
					81	.5864	.4136
				41	82	.5724	.4276
					83	.5578	.4422
			21	42	84	.5426	.4574
			17	.....	85	.5268	.4732
				43	86	.5103	.4897
					87	.4931	.5069
				22	88	.475	.525
					89	.456	.544
		9	18		90	.4359	.5641
				45	91	.4146	.5854
					92	.3919	.6081
				23	93	.3676	.6324
					94	.3412	.6588
				47	95	.3123	.6877
			19	.....	96	.28	.72
				24	97	.2431	.7569
					98	.199	.801
				49	99	.1411	.8589
5	10	20	25	50	100	.0000	1.0000

NOTE.

1. The ordinate at ¼ the semi-span from A towards D=¼ h √15 or .668h.
2. The ordinate at ½ the semi span=½ h √3 or .866h.
3. The ordinate at 3-5 the semi-span=4-5h.
4. The ordinate at 4-5 the semi-span=3-5h.
5. The co-ordinate at ¼ the semi-span=.0318h.
6. The co-ordinate at ½ the semi-span=.134h.
7. The co-ordinate at 3-5 the semi-span=1 5h.
8. The co-ordinates at 4-5 the semi-span=2-5h.

This note is applicable to the semi-elliptic and semi-circular works.

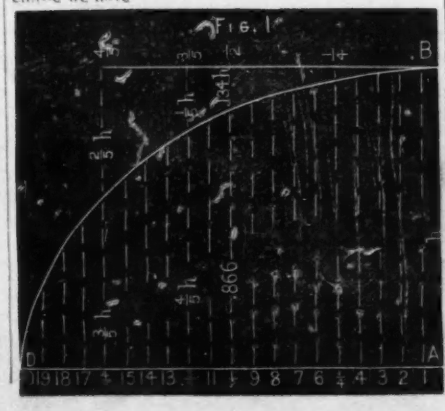
City Engineers Office,

DES MOINES, IA., Feb., 1875.

MR. EDITOR:—I send you the preceding Table which I have calculated for my own use. In the February number of the *London Artisan* appeared one by me over the signature of B. C. K., but the divisions were only carried to 40. In this one, I have carried them to 100 divisions, with a Table of co-ordinates which will be found useful in constructing templets for the masons. The table is applicable for semi elliptic and semi-circular arches.

Let A D (see fig.)=semi-span=s

A B=height=h. To find the ordinate x at 80-100 or 4-5 the semi-span from A towards D. From the ellipse we have



As $s \times s : h^2 :: (\frac{4}{5}s+s) \times \frac{1}{5}s : x^2$

or taking the extremes and means

$s^2x^2=(\frac{4}{25}s^2+\frac{1}{5}s^2)h^2$ and $x^2=\frac{9}{25}h^2 \therefore x=\frac{3}{5}h$

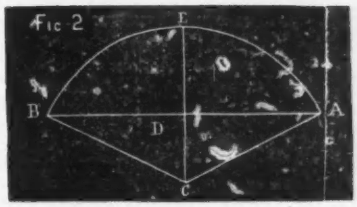
It is evident from the above result that in any semi-elliptic or semi-circular arch, if half the space is divided in the same proportions corresponding with the fractional parts given in the Table the only variable quantity will be the height of the arc.

Example of the use of the Table.

Given the span of an elliptic arch 36 feet and height A B=12 feet to find the ordinates.

Suppose we want 20 ordinates to half the span A D. Here we make use of 20 divisions at the top of the Table. Now 36-2=18 feet, the half span, and 18-20=.9, the length of each division, opposite 1 we get .9938, and .9938×12 feet, the height,=11.9856 feet, the ordinate for the first divison. Again, to find the ordinate for 5. Opposite 5 in the same vertical column we find .9682 and .9682×12, the height=11.6184 feet, the ordinate for the fifth division. Proceed in a similar manner with the other divisions.

The vertical numbers 1. 2, 3, 4, &c., are the numerators and the numbers marked divisions at the top of the column, are the denominators of the fractional parts of the semi-span.



Given the chord A B and height of an arc D E to find the radius. Let A D or B D, the half chord=c height of arc D E=h, radius B C=x.

C D=$(x-h)$ Then we have $x^2=c^2+(x-h)^2$

$$x^2=c^2+x^2-2hx+h^2$$

$$2hx=c^2+h^2$$

$$x=\frac{c^2+h^2}{2h}=\tfrac{1}{2}(c^2+h)$$

EXAMPLE.—Given the chord of a string course 40 feet; rise 1′3″, to construct a templet for the masons.

Now, $\frac{40}{2}=20$ half-chords, and by the above formula we have $\frac{(20)^2}{1.25}+1.25=160.625$ the radius.

Now we use 50 divisions and the column of co-ordinates, and $\frac{160.625}{50}=3.2125$ the length of each division; we get at 1=.0002, and .0002×160.165=.03125, the co-ordinate for 1, and for 2 we get .0008×160.165, the radius,=1.285 co-ordinate for 2.

We proceed in a similar manner for any other co-ordinates, which will construct templets for the masons rapidly.

B. C., City Engineer.

The first issue of the Baltimore "America," August 20th, 1772, contained an advertisement from George Washington, Engineer, offering for sale a tract of land bordering on the Ohio and Great Kanawha Rivers,